BETTER ALTERNATIVES NOW

B.A.N. LIST 2.0

An analysis and call-to-action to phase out the most polluting plastic products used in the United States

GOALS OF THIS REPORT

Identify the Top 20 plastic products and packaging that pollute U.S. watersheds

Provide the public, policymakers and environmental advocates with valuable data to drive campaigns

Share available data on brands associated with products on the B.A.N. List

Unravel the misinformation surrounding bioplastics

Discuss alternatives to the most common polluting products and packaging

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THE NATIONAL DATASET

INTRODUCTION

Over the last fifty years, plastic has become the packaging material of choice for many of the goods we consume. It's durable, lightweight, easily molded into different shapes and applications for marketing choices, and readily seals out oxygen and other contaminants. And plastic is artificially cheap. It dominates single-serve food and beverage packaging, carry-out shopping bags, and to-go containers and cutlery from restaurants and cafeterias. With Americans leading busier lives and eating on-the-go more than ever, all of that plastic is piling up.

This growing reliance on plastic to fuel our "culture of convenience" is not without cost. Globally, an average of eight million tons of plastic escapes collection systems, winding up in the environment and eventually the ocean[1]. Once there, sunlight and currents shred plastic debris into smaller particles called microplastics[2], which absorb and concentrate toxic chemicals up the marine food chain and into our bodies.[3] From plankton to fish, and to humans that eat seafood, plastic pollution is changing the very chemistry of life.[4]

> "Plastic—a material invented to last forever—can no longer be used to make products intended to be thrown away. There is no away."

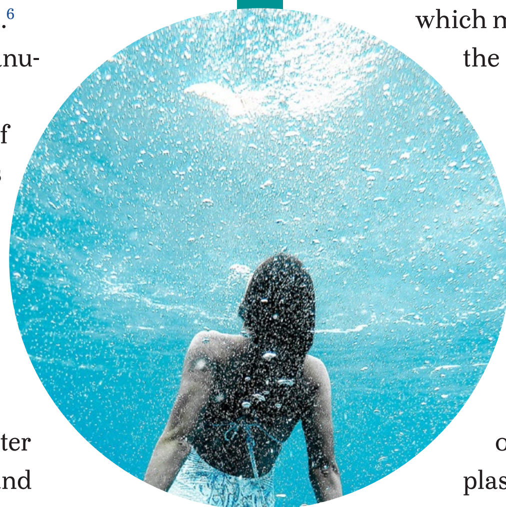
The true cost to the environment is mirrored by the impacts of plastic pollution on people. In our current linear economy, whereby the unregulated design of single-use, throw away products are ultimately buried or burned, the economic and human health effects are costly. Lower income communities typically become the neighborhoods where trash is collected the least, and in many cases where waste management systems are designated, including incinerator plants, new landfills, and material recovery facilities.

Plastic production is estimated to increase four-fold by 2050[5]. It is essential that the single-use, throw away culture end. Plastic—a material invented to last forever—can no longer be used to make products intended to be thrown away. There is no away.

TOXICITY

Research on microplastics and human health is an emerging field. Evidence of toxicity has raised concern about the chemistry of plastic polymers and common additives in the products we eat and drink from. In the marine environment, plastic pollution increases its toxicity over time through the absorption of persistent organic pollutants.[6]

Far upstream, where product manufacturing begins, different polymers were ranked based on the number of chemicals used. A chemical analysis showed that those polymers most commonly found in packaging, Polystyrene (PS), Polycarbonate (PC), and Polyvinyl Chloride (PVC) were of greatest concern to human health.[7] The polymer Polyethylene Terephalate (PET) scored slightly better in comparison to Polyethylene (PE) and Polypropylene (PP). The polymer Polylactic Acid (PLA) scored as least hazardous but this ranking does not take into account additives. Mixed into polymers to make products, many additives are known to be hazardous and increase the toxicity profile of individual plastic products.



Human contact with plastic products and packaging can cause some chemical toxicity due to the localized leaching of component monomers, endogenous additives, and adsorbed environmental pollutants. Chronic exposure is anticipated to be of greater concern due to the accumulative effect that can occur. This is expected to be dose-dependent, and robust evidence-base of exposure levels is greatly needed to better understand the potential mechanisms of toxicity and possible health effects.[8]

Research shows that plastic debris can be a vector for toxic chemicals in the marine environment. A study of floating plastic pollution found particularly high levels of polycyclic aromatic hydrocarbons (PAHs) on both PS foam packaging material and PS foam marine debris.[9] PAHs are known pollutants that are generated by incomplete combustion and used in many plastic manufacturing processes. This study demonstrates both the inherent toxicity of PS foam and its ability to accumulate pollutants in the marine environment. Another study that measured the accumulation of polychlorinated biphenyls (PCBs) and PAHs on different types of marine plastic pollution found that HDPE, LDPE, and PP contained higher concentrations of PAHs and PCBs than other polymers which more readily sank to the bottom of the ocean.[10]

The combination of toxic chemicals in manufacturing, plastic's persistence in the environment, and the increasing understanding that marine plastics hold the potential to deliver greater doses of toxic chemicals to marine life, all point to the need to dramatically reduce and redesign the use of plastics. Where it remains in use, plastic products and packaging should be manufactured using safer chemicals and designed with a circular economic model in mind. All additives must be available in full disclosure on the item, similar to the ingredient list required on food and beverage containers.

HOW IS B.A.N. LIST 2.0 DIFFERENT THAN B.A.N. LIST 1.0?

In B.A.N. List 1.0 we took a close look at the extent of plastic pollution on the California coastline. Quantity and type of plastics were measured on the ground by phone apps and beach surveys, resulting in a list of the top 15 most common products or packaging materials. We reported the kinds of polymers and additives used in those products and what we considered the best alternatives, ranging from reusables to paper or bioplastic alternatives. B.A.N. List 2.0 is much different.

B.A.N. List 2.0 analyzes data from the entire United States using the same sources to find the top 20 polluting products or packaging. Utilizing Litterati, a mobile app that allows users to document corporate logos or names on polluting plastics, we can assign some brand names to those items. B.A.N. List 2.0 can be used to encourage companies to address their part of the plastic pollution problem.

In B.A.N. List 2.0, we also present a case study of bioplastic degradation as it relates to consumer expectations to answer the question, "Are bioplastics the answer?" We tested 20 bioplastic and biopolymer-based products that made claims about their environmental performance. Our results show that what products advertise, what consumers think, and how products perform are generally inconsistent, exposing potential "greenwashing" and a need for public education and truth in advertising.

METHODOLOGY AND ANALYSIS

In order to identify the products and packaging that are causing the most harm in the environment and for human health, 10 organizations partnered to create the B.A.N. List 2.0 (Better-Alternatives-Now). We examined publicly available data sources to determine which plastic applications perform the worst from a pollution standpoint (e.g. what's found in the environment). We expanded our analysis to include datasets from across the United States.

There are multiple sets of data collected by different organizations that document environmental contamination by product types and/or brand identification. For the B.A.N. List 2.0, datasets from Ocean Conservancy's International Coastal Cleanup Day, NOAA's Marine Debris Tracker, Clean Ocean Action, Project Aware, and Heal the Bay were referenced. Available data on the top 20 items by count were combined, resulting in a hierarchy beginning with the most common contaminant (food wrappers).

With this list of the top 20 items, we worked with the mobile app Litterati to share the top 5 brands identified for each product/packaging item category. Nine of those 20 categories had brand data.

Our analysis adds to a growing body of data highlighting the urgent need for action. We're demanding that policy makers and business leaders take immediate action to phase out these harmful plastics, and build systems of circularity into the design of their products. Better alternatives are needed now, either through government regulatory action, voluntary efforts by industry, or both.

BREAK FREE FROM PLASTIC—A SNEAK PEAK AT B.A.N. LIST 3.0

HUNDREDS OF NONGOVERNMENTAL organizations (NGOs) worldwide have come together to stop plastic pollution. We are building a movement with common values of environmental protection and social justice, and these shared values guide our work in building the world in which we wish to live.

In September 2017 in Manila, Philippines, several member groups under the global #breakfreefromplastic movement spent 8 days on Freedom Island to conduct a brand audit. The results revealed that six international brands are responsible for 53.8% of plastic packaging pollution found in the designated ecotourism area, which has been declared as a critical habitat for migratory birds.

International brands are among the worst oceans polluters—and the global #breakfreefromplastic movement is holding them accountable.

In 2018 B.A.N. List 3.0 will compare the U.S. plastic trash audit to datasets from Southeast Asia, with a focus on brand accountability.

MEGRED NATIONAL DATASETS: THE TOP 20 PRODUCTS

PLASTIC PRODUCT	COUNT							
	ICC	NOAA	MDT	Heal The Bay	COA	Project AWARE	TOTAL	%
1 Food Wrappers (candy, chips, etc.)	318880.0	272.0	16315.0	307.0	14827.0	217.0	**350818.0**	**18.6**
2 Bottle Caps (Plastic)	273089.0	779.0	11735.0	27352.0	2328.0	205.1	**315488.1**	**16.7**
3 Beverage Bottles (Plastic)	206993.0	122.0	7809.0	6297.0	5508.0	289.0	**227018.0**	**12.0**
4 Bags (Plastic)	157702.0	39.0	6970.0	5249.0	7871.0	313.0	**178144.0**	**9.4**
5 Straws, Stirrers	125635.0	172.0	4645.0	4026.0	8102.0	165.0	**142745.0**	**7.5**
6 Lids (Plastic)	75921.0	186.9	409.0	5829.5	15347.0	57.9	**97751.2**	**5.1**
7 Utensils	42599.0	33.0	1848.0	47133.0	1864.0	352.0	**93829.0**	**4.9**
8 Cigarette Butts*	51550.5	25.3	2337.9	6775.9	643.0	9.1	**61341.7**	**3.2**
9 Take Out/Away Containers (Foam)	41805.0	102.9	537.7	17696.0	548.0	8.3	**60697.8**	**3.2**
10 Take Out/Away Containers (Plastic)	49973.0	123.0	37.0	5624.0	1021.7	9.9	**56788.6**	**3.0**
11 Cups, Plates (Plastic)	48559.0	14.6	732.6	1862.2	1766.0	9.6	**52943.9**	**2.8**
12 Cigar Tips	41211.0	47.0	328.0	6243.0	2351.0	16.0	**50196.0**	**2.6**
13 Cups, Plates (Foam)	42047.0	12.4	4495.7	690.0	2021.0	8.3	**49274.5**	**2.6**
14 Tobacco Packaging/Wrap	33434.0	82.3	604.5	352.0	694.0	19.0	**35185.8**	**1.8**
15 Balloons	23492.0	19.0	1442.0	5263.0	480.3	13.0	**30709.3**	**1.6**
16 Other Plastic Bottles	17548.0	62.0	1578.0	4769.6	1429.0	9.0	**25395.6**	**1.3**
17 Cigarette Lighters	10750.0	24.0	676.5	10750.0	405.0	3.0	**22608.5**	**1.2**
18 Personal Care Products (condoms & tampon applicators)	11555.0	37.4	827.5	2213.2	1875.1	14.0	**16522.2**	**0.8**
19 6-Pack Holders	8224.0	3.0	180.0	641.0	130.0	10.0	**9188.0**	**0.4**
20 Diapers	3938.0	12.5	276.8	2150.6	82.0	7.0	**6466.9**	**0.3**
Sum Total	**1584905.5**	**2169.3**	**63785.2**	**161223.9**	**69293.0**	**1735.1**	**1883112.0**	**100.0**

* *Counts of cigarette butts were divided by 20 to represent packs rather than individual cigarettes.*

MERGED NATIONAL DATASETS

To create common categories of plastic products and packaging among these six datasets, we made assumptions to split or lump numbers together, such as counting cigarette butts as packs (20 butts per pack) rather than individually, or lumping personal care products, like ear buds or tampon applicators, into one category. These assumptions made sense and made datasets more comparable. This exercise also uncovered challenges and opportunities in how to mitigate specific types of pollution.

MATERIALS IN THE TOP 20 PRODUCTS

PLASTIC PRODUCT	IN ENVIRONMENT COUNT	%	LIKELY PLASTIC-TYPE (POLYMER)	BETTER ALTERNATIVES NOW	BEST ALTERNATIVES NOW
1 Food Wrappers (candy, chips, etc.)	350818.0	18.6	Several different plastics**	More work needed on bio-benign alternatives	Bulk purchasing of food in reusable containers
2 Bottle Caps (Plastic)	315488.1	16.7	Polypropylene (PP #5)	"Connect the Cap" technical fix available	Functional replacement with reusable bottles
3 Beverage Bottles (Plastic)	227018.0	12.0	Polyethylene terephthalate (PET #1)	Increase deposit to increase collection rates	Functional replacement with reusables
4 Bags (Plastic)	178144.0	9.4	Primarily Low-Density polyethylene (LDPE #4)	Natural, bio-based shopping bags (paper)	Functional replacement with reusable bags
5 Straws, Stirrers	142745.0	7.5	Polypropylene (PP #5)	Paper or wood straws/stirrers	Functional replacement with reusable straws/stirrers
6 Lids (Plastic)	97751.2	5.1	Polystyrene (PS #6)	More work needed on bio-benign alternatives	Functional replacement with reusable cups
7 Utensils	93829.0	4.9	Polystyrene (PS #6)	Natural, bio-based biodegradable utensils (bamboo/wood)	Functional replacement with reusable utensils
8 Cigarette Butts*	61341.7	3.2	Cellulose Acetate Fiber	Filter-less cigarettes	Plant-based biodegradable cigarette filters
9 Take Out/Away Containers (Foam)	60697.8	3.2	Polystyrene (PS #6)	Plant-based biodegradable take-out containers	Functional replacement with reusable take-out containers; work to change health codes to enable this change
10 Take Out/Away Containers (Plastic)	56788.6	3.0	Several different plastics**	Plant-based biodegradable take-out containers	Functional replacement with reusable containers ***
11 Cups, Plates (Plastic)	52943.9	2.8	(PS #6) & (PET #1)	Plant-based biodegradable cups	Functional replacement with reusable cups
12 Cigar Tips	50196.0	2.6	Polystyrene (PS #6)	Functional replacement with reusable cigar tips	Ban of smoking in public space
13 Cups, Plates (Foam)	49274.5	2.6	Polystyrene (PS #6)	Plant-based biodegradable cups	Functional replacement with reusable cups ***
14 Tobacco Packaging/Wrap	35185.8	1.8	Polypropylene or Polyethylene (#5 or #2)	Plant-based biodegradable alternatives	Natural bio-based materials, like cellulose
15 Balloons	30709.3	1.6	Latex or Mylar	Plant-based biodegradable alternatives	Cultural alternatives to balloon releases
16 Other Plastic Bottles	25395.6	1.3	Several different plastics**	Increase deposit to increase collection rates	Functional replacement with reusable bottles
17 Cigarette Lighters	22608.5	1.2	Polycarbonate (PC - #7)	See best alternative	Functional replacement with matches or refillable non-plastic lighters
18 Personal Care Products (condoms & tampon applicators)	16522.2	0.8	Several different plastics**	See best alternative	Natural bio-based materials
19 6-Pack Holders	9188.0	0.4	Low density polyethylene (LDPE #4)	Plant-based biodegradable alternatives	Paper box beverage holders
20 Diapers	6466.9	0.3	Several different plastics**	Plant-based biodegradable alternatives	Cloth diaper services when available

** Counts of cigarette butts were divided by 20 to represent packs rather than individual cigarettes.*
*** These products are made from several different types of plastic, and a full analysis for each product is not included here.*
**** In many cities, this will require new health codes to permit reusable containers in this context.*

TOP 5 BRANDS IN EACH PRODUCT CATEGORY

PLASTIC PRODUCT	#1 BRAND / # OF ITEMS**	#2 BRAND / # OF ITEMS**	#3 BRAND / # OF ITEMS**	#4 BRAND / # OF ITEMS**	#5 BRAND / # OF ITEMS**
1 Food Wrappers (candy, chips, etc.)	Wrigley's / 394	Trident / 344	Starburst / 169	Snickers / 166	- / -
2 Bottle Caps (Plastic)	Coke / 20	Gatorade / 15	Naked / 3	Snapple / 2	Crystal Geyser / 2
3 Beverage Bottles (Plastic)	Poland Springs / 106	Gatorade / 82	Coke / 37	Crystal Geyser / 36	Arrowhead / 27
4 Bags (Plastic)	Starbucks / 50	McDonalds / 49	Taco Bell / 9	- / -	- / -
5 Straws, Stirrers	Starbucks / 133	McDonalds / 132	Dunkin Donuts / 25	Burger King / 16	Subway / 12
6 Lids (Plastic)	- / -	- / -	- / -	- / -	- / -
7 Utensils	- / -	- / -	- / -	- / -	- / -
8 Cigarette Butts*	Marlboro / 2099	Camel / 791	Parliament / 688	Newport / 472	Pall Mall / 247
9 Take Out/Away Containers (Foam)	- / -	- / -	- / -	- / -	- / -
10 Take Out/Away Containers (Plastic)	- / -	- / -	- / -	- / -	- / -
11 Cups, Plates (Plastic)	Starbucks / 315	McDonalds / 187	Taco Bell / 56	Dunkin Donuts / 54	Peets / 43
12 Cigar Tips	- / -	- / -	- / -	- / -	- / -
13 Cups, Plates (Foam)	- / -	- / -	- / -	- / -	- / -
14 Tobacco Packaging/Wrap	Swisher Sweets / 249	Dutch / 76	Backwoods / 49	- / -	- / -
15 Balloons	- / -	- / -	- / -	- / -	- / -
16 Other Plastic Bottles	- / -	- / -	- / -	- / -	- / -
17 Cigarette Lighters	- / -	- / -	- / -	- / -	- / -
18 Personal Care Products (condoms & tampon applicators)	Trojan / 5	Lifestyles / 2	Pleasure Plus / 1	- / -	- / -
19 6-Pack Holders	- / -	- / -	- / -	- / -	- / -
20 Diapers	- / -	- / -	- / -	- / -	- / -

** Counts of cigarette butts were divided by 20 to represent packs rather than individual cigarettes.*
*** The # of items represents the total number of products identified as that specific brand in 2016.*

TOP 5 BRANDS IN EACH PRODUCT CATEGORY

Brands were identified by the company's logo, its font style of any text, and/or the shape of the product or its packaging. The task was complicated by items being fragmented, and degraded or faded by sunlight. In one recent analysis of 1200 items collected by volunteers in the San Francisco Bay area, only 19% of items had recognizable brand information.[11] This data is hard to get.

In this analysis, we relied on information available from the mobile app "Litterati", whereby users photograph trash and have an option to write in brand information. Litterati utilizes brand data to share with brand owners, encouraging them to find more sustainable solutions. Our study gathered data on 9 of the 20 categories we had created. However, since many of the brand categories are generic, like utensils and foam cups, brand identification can be challenging.

Our data is also influenced by a brand's market share. For example, Marlboro is the dominant cigarette brand for U.S. consumers, with 32% market share, which may explain its dominance as litter. Regardless of whether the brand tops the B.A.N. List because of high consumer purchasing or littering, alternatives are critical to protect public and environmental health.

Given these caveats, the table "Top Brands in Each Category" presents the best available top five brands identified in eight categories.

ARE BIOPLASTICS THE ANSWER?

AN OVERVIEW

WHAT ARE BIOPLASTICS?

There is much confusion surrounding terms such as biodegradable and compostable, as well as bioplastic, bio-based, bio-polymer, etc. While all of these terms have specific meanings, they are confusing to consumers. This confusion is often created by misleading, suggestive, and unclear marketing claims—statements, words, images and even packaging color and design. Terms such as "compostable", "biodegradable" or "ecofriendly" are used frequently on packaging in ways that confuse the public. This problem is compounded by the use of similar images and terms on plastics derived from fossil fuels in an attempt to gain customers who are seeking environmental attributes they believe bioplastics have.

Bioplastics and bio-based plastics are made from renewable feed stocks (biomass), like the leftover pulp from harvesting sugarcane. The feedstock however doesn't determine its compostability or biodegradability, the molecular structure does. Therefore using the word "Bioplastic" doesn't tell you anything about its performance in the environment, or its recyclability. Let's break it down.

Bio-based plastics are produced from monomers derived from biomass, like fermenting plant carbohydrates into ethylene, which can then be polymerized into polyethylene (PE). You can also make PET the same way. PET is the plastic polymer that water bottles, for instance, are commonly made of, and while nearly all PET water bottles are made from fossil fuel-derived plastic, PET can also be made from biomass, and is called bio-PET. Bio-PET, bio-PP, or bio-PE are no different than PET, PP or PE, the feedstock is just different—and none of them are compostable or biodegradable.

Bio-derived plastic is a mixture of plastics derived from both feedstocks, modern plants and fossil fuels. Having some of the feedstock come from modern plants allows companies to advertise with ambiguous words like "green" and "natural", and depicting green leaves and trees in their graphics. One example is the "Plant Bottle", a product from Coca Cola. Derived from up to 30% plant material and 70% or more other feedstocks, it is still 100% polyethylene. While the plant bottle is recyclable, it is not biodegradable or compostable, though the leaf in its design suggests otherwise.

Biopolymers, the truly biodegradable plastics, are made from a natural substance, such as chitin or cellulose, polylactic acid (PLA) made from plants, or the polymer polyhydroxyalkanoate (PHA), which is naturally produced by bacteria. Producing bioplastics is a matter of extracting the polymer from the biomass directly. Although in some cases, like the textile rayon or cellulose acetate used for cigarette butts, the polymer is chemically modified to give it more durable properties for commercial use, so they resist biodegradation. PHA and PLA are the most common commercially used bioplastics for consumer goods. But these biopolymers, while considered compostable, are designed to be composted in industrial compost facilities, not backyard compost bins or the environment. This leads to further public confusion about which bin those products go in, or what happens if they become litter or enter the marine environment.

So, which ones are biodegradable or compostable? Bio-based and bio-derived plastics are neither, so they need to enter the recycle stream, and must be labeled in a way that doesn't mislead the public. When we talk about biodegradation, we mean that the polymer breaks down into smaller molecules, such as CO2, CH4 and H2O by microbial digestion. Biopolymers like PHA and PLA are biodegradable, but have very specific conditions where degradation happens. These conditions are not found in soil, home compost bins or the marine environment. According to most of the companies that use PHA or PLA, the ocean or a backyard compost bin is not considered an acceptable disposal environment for their product, although terms like "compostable" and "biodegradable" are still commonly used on packaging.

In summary, there's too much confusion. There is a need for consistent labeling on *all* products and packaging, using industrial standards (ASTM, ISO, EN) and more "truth in advertising" so the public understands how to be responsible with their bioplastics, and what happens if they become litter.

MAKING SENSE OF TERMS & STANDARDS: READING BETWEEN THE LINES

The difference between *biodegradability* and *compostability*, two terms commonly used interchangeably on products and packaging, are unclear to consumers and may lead to misconceptions and uninformed purchasing. As consumers demand more "green products," advertisers make claims that are easily misinterpreted.

"There's too much confusion. There is a need for consistent labeling on *all* products & packaging, using industrial standards... **so the public understands how to be responsible with their bioplastics.**"

The Federal Trade Commission (FTC) has produced "Green Guides" to give producers some guidance. For example, the term *degradable* must only be used for materials that return to nature in a reasonable time frame, stating that "marketers must not make unqualified degradable claims for items destined for landfills, incinerators, or recycling facilities because complete biodegradation in those specific environments will not occur within one year."[12] The FTC states that to claim a product is compostable there must be reliable scientific evidence that all materials in the product or package will break down into usable compost in a safe and timely manner in an appropriate composting facility; "timely" meaning that it breaks down with other natural composting materials.[13]

In most cases, products and packaging refer to industrial standards that back up their claims, such as the "fine print" for numbers that begin with ASTM (American Society for Testing and Materials), EN (European Standard or literally "European Norms") or ISO (International Organization for Standardization). These are objective tests that define how a material behaves. So when a package label reads, "We conform to ASTM 6400" it means that bacteria can break down the packaging in a setting over 50°C, which may be achievable in a municipal composting facilities, but not typically in your backyard compost bin. These tests are used by companies to abide by FTC rules to clarify compostability or degradability.

California has some of the most strict "truth in advertising" guides in the country,[14] recently passing SB 567 that expands the current scope of labeling requirements from bags and food packaging to all plastic products. The term biodegradable cannot be used on any plastic product whatsoever. Unless a product or packaging is truly compostable or marine degradable by established standards, like the European Vincotte OK Compost HOME Certification, then those terms cannot be legally used.

To better identify and certify that industrially compostable plastics really do meet applicable ASTM standards (ASTM D6400 and ASTM D6868), and are not suitable for backyard composting, BPI (Biodegradable Products Institute) provides a review and certification of testing results that allows a product to be labeled as certified compostable using the BPI Compostable Label.[15] Even with this certification, there are sometimes mixed results at compost facilities due to the wide range of parameters and technologies used at these facilities. That is why some cities, such as the City of Seattle, also require "field testing" at local compost facilities. Cedar Grove Composting has long been known for field testing compostable packaging, which can use the Cedar Grove Compostable label if shown to successfully compost. To address that there are a number of different industrial compost facility technologies in use, the Compost Manufacturing Alliance now provides field testing services using a variety of compost technologies.[16]

The Biodegradable Products Institute seal.

There is an additional category of materials that are particularly problematic and confusing. These blend plant based materials, such as starch, with fossil fuel based plastic, such as polypropylene. These materials are not biodegradable, compostable or recyclable, but are claimed to be superior because they reduce their fossil fuel use through using some renewable materials in their make up.

LET'S DEFINE SOME OF THESE COMMON STANDARDS:

ASTM D6400 tests whether the material is compostable in a municipal composting facility. This test lasts a minimum of 90 days, but up to 180, testing microbial degradation at consistent temperatures greater than 50°C. Exposed to an inoculum derived from a municipal waste stream, the material should biodegrade completely.

ASTM D5338 is a standard biodegradation test that measures aerobic biodegradation of plastic materials under controlled composting conditions for a minimum of 90 days. ASTM D5338 is a core component of ASTM 6400 Compostability Test Method, which is recognized by many regulatory agencies and municipalities, and the FTC as a requirement for making biodegradability claims about a product or material. It's primarily used for materials that have not made it to the waste stream yet, often being used for materials intended to test food and beverage containers.

ASTM D5511 tests anaerobic biodegradation of plastic materials under high-solids anaerobic-digestion conditions. This procedure has been developed to permit the determination of the rate and degree of anaerobic biodegradability of plastic products when placed in a high-solids anaerobic digester for producing compost from municipal solid waste. The test measures degradation under accelerated conditions and does not show real world composting/landfill conditions. It's important to note that this is a measure of degradation, rather than a pass/fail test. It was been incorrectly used by companies and municipalities to claim that a material is "proven" to degrade in landfills. This test method is equivalent to ISO 15985.

ASTM D6868 tests the compostability of biodegradable plastic linings and coatings for products and packaging that want to claim, "compostable in municipal and industrial composting facilities." It must compost at a rate similar to other compostable materials and not diminish the quality of the resulting compost. This specification covers biodegradable plastics and products (including packaging), where plastic film or sheet is attached (either through lamination or extrusion directly onto the paper) to substrates and the entire product or package is designed to be composted.

ASTM D6691 tests the biodegradabilty of bioplastics in marine sediment at temperatures as high as 28C. It has been used by some companies to claim "marine degradable," though in the ocean, temperatures in deeper waters fall well below this (4C at 2000 m). Testing bioplastic degradation in a relatively warm, microbe-rich laboratory setting is very different from the cold, dark environment where microbial activity slows down. Since PHA and PLA sink in seawater, they would likely remain intact for a very long time.

ASTM D6954 measures the degree to which plastics degrade in the environment by a combination of oxidation and biodegradation.

EN 13432 sets limits on the kind of chemical additives used (Cu, Zn, Ni, Cd, Pb, Hg, Cr, Mo, Se, As and fluoride) and requires biodegradation of 90% of the material in six months or less. It also requires that physical decomposition in the first three months be defined by a 90% breakdown of the material into particles less than 2x2mm.

ISO 14855 is a test that determines ultimate biodegradation of plastic materials under composting conditions. It measures the anaerobic biodegradation by the analysis of carbon dioxide created by microorganisms during the biodegradation process. Like D6400, this test is for a minimum of 90 days and reflects composting conditions similar to an industrial composting facility, not a backyard compost bin.

ASTM D7081 tested whether or not materials are marine degradable. (*This standard has been withdrawn and not replaced as of 2017*). This specification covered plastic products (including packaging and coatings) designed to be biodegradable under the marine environmental conditions of aerobic marine waters or anaerobic marine sediments, or both, in 30 °C for 180 days. (Possible environments are shallow and deep salt water, as well as brackish water. This specification is intended to establish the requirements for labeling materials and products, including packaging, as "biodegradable in marine waters and sediments."

There are a variety of home compostability certifications, including those used in (left to right) Germany, Belgium, and Australia & New Zealand.

Home Composting Certifications.[17] There are two that specify home compostability: DIN CERTO in Germany and Vin-Cotte in Belgium. Australia and New Zealand use AS 5810[18] for home compostable plastics, which require that after 180 days all of the material must pass through a 2mm sieve and leave zero toxicity from the material, inks, dyes, or other additives.

BAN OXO-BIODEGRADABLES

Polyethylene, polypropylene or polystyrene combined with a metal salt additive to speed up the oxidation process is known as oxo-biodegradable plastic. These plastics are not considered compostable according to ASTM D6400 and EN13432, primarily because they do not meet the 180 day degradation limit, even in a high-heat municipal composting environment. There are additionally many cases where degradation results in fragmentation, leaving residual microplastic behind. One study of oxo-biodegradable plastic bags in the marine environment found that after 40 weeks more than 90% of the material was still present.[19] In other similar studies, degradation was found to be incomplete.[20] Because of the lack of environmental performance relative to claims, some countries are considering bans on oxo-biodegradable packaging.[21] The New Plastics Economy has organized over 150 organizations and companies to support a global ban on oxo-biodegradable plastics.[22]

ARE BIOPLASTICS THE ANSWER?

THE CASE STUDY

FOCUS

This case study is focused on understanding the performance of bioplastic products and packaging in two realistic settings. These settings—the ocean and a typical backyard compost bin—were established for two years. Twenty different items were placed in each setting. The results show that most bioplastic products persist in the environment like their petroleum-based plastic counterparts. Therefore, the same argument made for restricting single-use disposable plastic products should apply to bioplastic products.

METHODOLOGY

To understand the performance of a variety of products using confusing terms and claims about their degradation properties—like cups, utensils, straws and bags—we collected 20 different products made from PLA (polylactic acid) and PHA (polyhydroxyalkanoate), as well as some non-bioplastic polyethylene-lined products.

One important caveat to note here: some of these products claim that they must be placed in an industrial composting facility, where large piles of decomposing natural materials provide a microbe-rich, moist and warm setting for decomposition. What happens however when these products are lost in the environment, like many other single-use, throw away types of packaging? To answer this question, we tested them in real environmental conditions on land and in the sea: a home compost box and under a dock in a saltwater marina.

We made 4 sets of each of the 20 products and packaging, burying one in a backyard compost box for 6 months, a second for 12 months, and the last for two years. The composting environment was an open-air box, with the items placed in clay flower pots, and then buried 6 inches and left untouched in the composting bed until recovered. This served as a stand-in "best case" scenario for if that product was littered on land and was in contact with soil. It was not meant to simulate an actively managed and turned home compost system or an industrial compost environment.

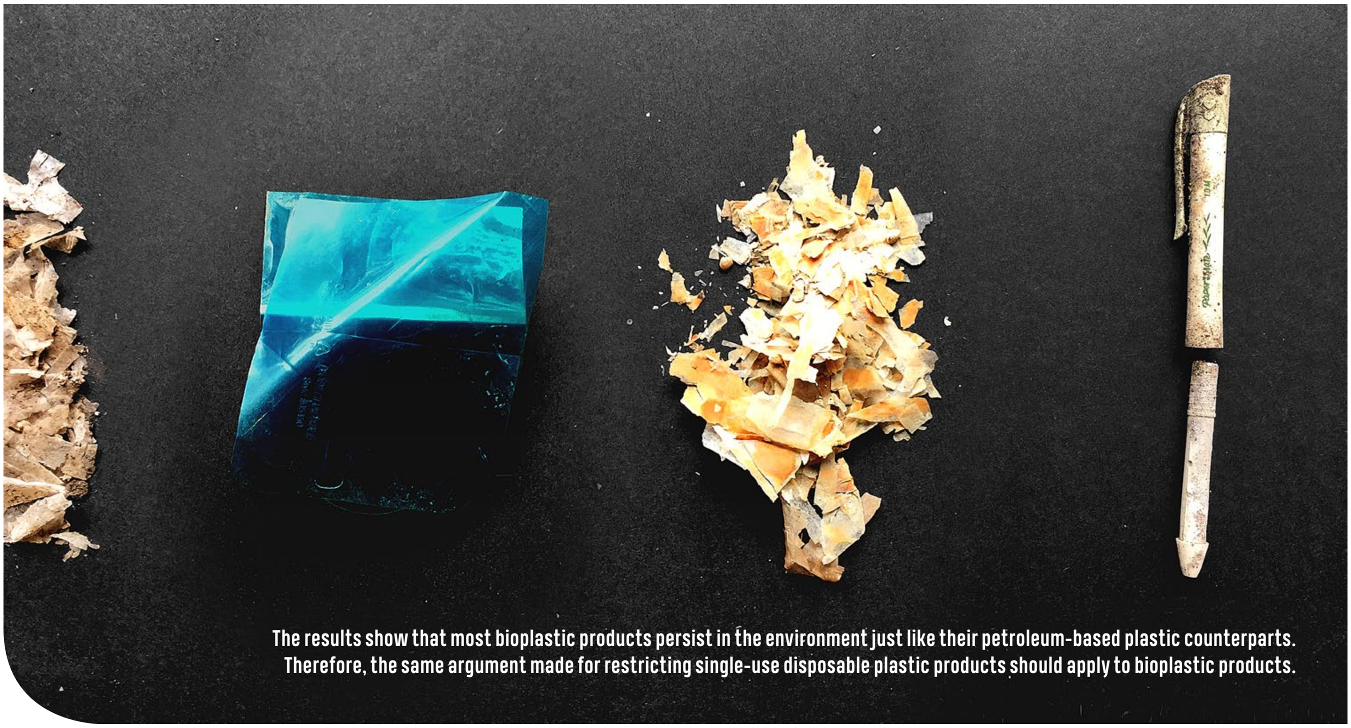
The fourth set was submerged under a dock in the ocean for 2 years. Each of the 20 items was put into a 1/3 mm mesh nylon bag, then positioned side-by-side in the crate, weighted by a layer of bricks on the bottom.

One set of plastic products was tested by submerging it under a dock in the ocean for 2 years.

LESSONS LEARNED FROM THE CASE STUDY

1 **Test in real conditions with real products.** The purpose of this case study was to understand what happens to bioplastic products and packaging that enter the environment, whether it's the ocean or side of the road, or tossed in an average residential compost bin. ASTM, ISO and other tests often use "raw" feedstocks of biopolymers, rather than finished products that contain different plasticizers, like colorants, UV resistant agents, labels and laminates. The ASTM standards used to define the degradation of bioplastics need to mimic real conditions, such as in the ocean, where bioplastic might interact with biota, be impacted by waves, or buried under sediment. While our "sunken crate" mimicked burial in the marine environment, there's more to the story of how bioplastics behave in the marine environment. Testing the whole product, with labels and caps on, laminates of paper and metal intact, and in real environmental conditions will help better understand the true life cycle of bioplastics.

2 **Labels need to be clear for consumers, recycling centers and composting facilities.** Terms like "ecofriendly" or "degradable" can be misleading to consumers, but companies can be more clear if they use testing standards.[23] Of the 16 bioplastic products in this case study, only five referenced specific ASTM or ISO standards for *degradability* or *compostability*. To avoid confusion, contamination and improve proper collection, accurate certification and labeling are essential for all bioplastics. For example, a PLA cup accidentally mixed with PET bottles contaminates and devalues the recycled polymer. With no such labeling, management becomes a guessing game with the likely result that the bioplastic products end up in landfill or being incinerated.



The results show that most bioplastic products persist in the environment just like their petroleum-based plastic counterparts. Therefore, the same argument made for restricting single-use disposable plastic products should apply to bioplastic products.

3 **Fragmentation is not biodegradation.** Only the paper straw, starch packing peanuts and PHA beach toy decomposed beyond visual observation. In all other cases, objects either stayed whole or fragmented into smaller pieces. Volatile compounds added to plastic to make them flexible or UV resistant often oxidize, leaving the remaining plastic polymer brittle and vulnerable to fragmentation by mechanical forces. The polymer is still there, just in smaller pieces. It is important not to confuse fragmentation with degradation. However, pitting or peeling on the surface of biodegradable plastic products usually does indicate microbial activity and biodegradation.

4 **Bioplastics are not functional replacements for the majority of single-use, throw away products.** While the ideal packaging material would be like the skin of a grape—biodegradable in all environments (compost facilities, on land, and in water)--most bioplastics are not. The products and packaging studied here did not degrade in time frames similar to natural materials, if they even degraded at all. As more composting facilities open, and the volumes of material they receive drive them to demand fast and reliable composting rates, bioplastics are not performing as expected. Given the lack of ideal bioplastic material for all environments, following the waste hierarchy continues to make sense: reduce (eliminate use in first place), opt for reusables, and as a last resort, recycle and compost.

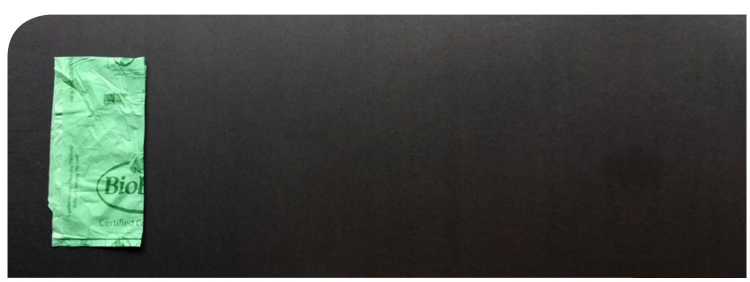
5 **The right place for biodegradable plastics.** An anonymous PHA manufacturer suggested that the market for bioplastics will be found, "in environments where degradation is desired, like agricultural films to cover crops to keep moisture in and weeds out, therefore improving harvest and leaving a nutritive material to be composted. Also in aquaculture, where occasional loss of gear to the sea happens, biodegradable plastic components eliminate long lasting waste."

6 **Increasingly, many municipalities are diverting residential food waste away from landfills with curbside collection.** In several cases biodegradable bags are allowed to contain food waste destined for municipal composting facilities.

CASE STUDY RESULTS BY CATEGORY

The 20 products were divided into four groups:

BAGS

PRODUCT	STANDARDS & CLAIMS	ENVIRONMENTAL PERFORMANCE (New / 6 mo. on land / 12 mo. on land / 24 mo. on land / 24 mo. in the sea)
 PrideGreen Zip-lock bags	Oxo-assimilation ASTM D6954-04. Landfill degradation in 18-36 months.	
 Bags on Board Pet waste bags	Environmentally friendly	
 Bio Bag Bags	Certified compostable. Meets ASTM D6400.	

BAGS

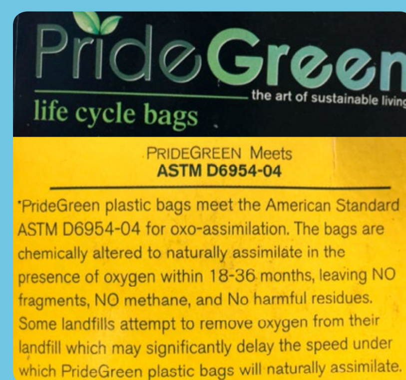
Three kinds of bags were tested:

- Bags on Board pet waste bags
- Pride Green ziplock bags
- Bio Bags bags

The Bags on Board pet waste bag is made of polyethylene, and as suspected, remained intact in both land and sea environments over the 2 years. The Pride Green bag is an oxo-biodegradable polymer, resulting in our test in fragmentation on land and no change at all after 2 years in the ocean. The label states it conforms to ASTM D6954—environmental degradation through a combination of biodegradation and oxidation, but in this test in real conditions as environmental pollution, it did not degrade.

The best performing of the three was the Bio Bag, which disintegrated on land in 6 months and was completely disintegrated in the ocean after 2 years. The polymer for this plastic is called Matter-Bi, described on the company website as a "pioneering proprietary technology using starches, cellulose, vegetable oils and their combinations", and advertising industrial and home composting, under ASTM D6400. While this bag degraded in all environments, we do not recommend any bioplastic polymer as a functional replacement for single-use throw away grocery bags. Although, many communities that are developing residential food waste collection are permitting collection bags, like BioBags, because of their ability to hold wet organic waste and still degrade efficiently in industrial composting conditions.

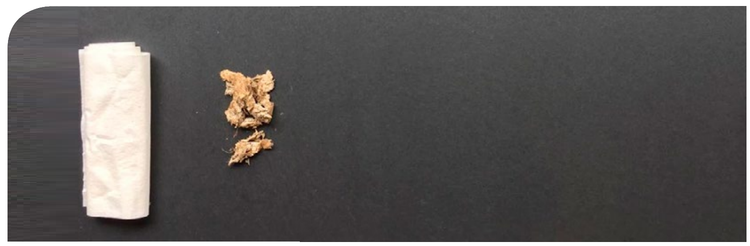
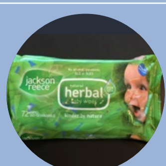
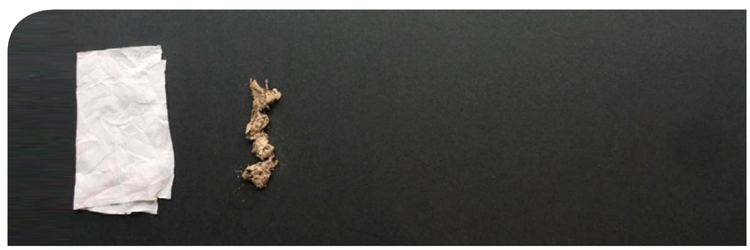
BAGS ON BOARD PET WASTE BAGS



PRIDE GREEN ZIPLOCK BAGS

BIO BAGS

BABY WIPES & DIAPERS

PRODUCT	STANDARDS & CLAIMS	ENVIRONMENTAL PERFORMANCE
		New / 6 mo. on land / 12 mo. on land / 24 mo. on land / 24 mo. in the sea
 Eco Natural Diapers	Fully compostable*, EN 13432, ASTM D6400 (*compostable in some municipal facilities)	
 Eco-Me Baby Wipes	Made of natural materials. Please recycle wipes.	
 Huggies Baby Wipes	Breaks up after flushing. Safe for sewer and septic systems.	
 Jackson Reece Natural Herbal Baby Wipes	Biodegradable. Kinder by nature.	
 Earth-Friendly Baby Baby Wipes	100% Biodegradable and kinder to the environment	
 Elements Naturals Baby Wipes	100% natural and compostable. Compostable to ISO, ASTM, EN regulations.	

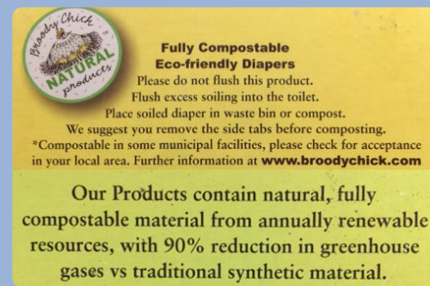
BABY WIPES & DIAPERS

There were six products compared in this category:

- Eco-natural diapers
- Eco-Me baby wipes
- Huggies baby wipes
- Jackson Reece Natural Herbal baby wipes
- Earth Friendly Baby baby wipes
- Elements Naturals baby wipes

Of these, the diapers remained unchanged in all environments over time. Recycling these diapers is nearly impossible because the diaper's liner, outer shell, and the absorbent are all different polymers.

Element Naturals baby wipes, made from PLA branded as "Ingeo", did not degrade on land, but were completely degraded in the ocean. The other four brands of baby wipes were completely disintegrated after 12 months on both land and in the ocean in all time frames. Only one of the four brands, Jackson Reece, identifies the polymer, describing it as a cellulosic fiber from plant material.



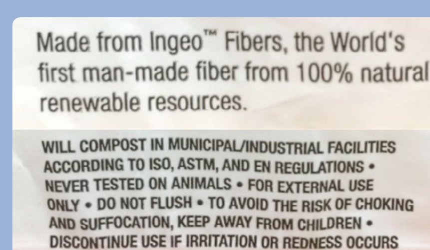
ECO-NATURAL DIAPERS

ECO-ME BABY WIPES

HUGGIES BABY WIPES

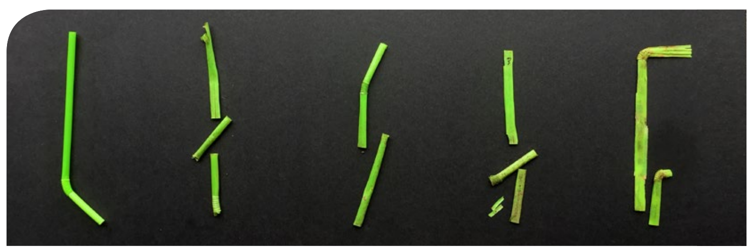
JACKSON REECE NATURAL HERBAL BABY WIPES

EARTH FRIENDLY BABY BABY WIPES,



ELEMENTS NATURALS BABY WIPES.

CUPS, STRAWS & UTENSILS

PRODUCT	STANDARDS & CLAIMS	ENVIRONMENTAL PERFORMANCE: New / 6 mo. on land / 12 mo. on land / 24 mo. on land / 24 mo. in the sea
 Eco Products Cold Cups	Compostable BPI certified, made from corn	
 Planet Compostable Hot Cups	Compostable. Made from Ingeo, a brand name for PLA.	
 Aardvark Paper Straws	Described as "Earth-friendly".	
 World Centric PLA Straws	100% compostable, ASTM D-6400, EN13432. Breaks down in commercial compost.	
 Rossetto Cutlery	Compostable, natural materials.	
 Bio-Based Eco-Products PSM Cutlery	Made from 70% renewable resources. Not compostable.	

CUPS, STRAWS & UTENSILS

There were six products compared in this category:

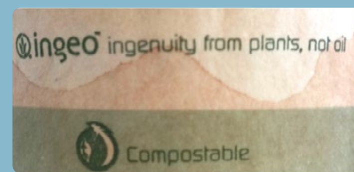
- Eco Products cold cups
- "Planet" coffee cup (lined with Ingeo, a brand of PLA)
- Aardvark paper straws
- World Centric PLA straws
- Rossetto utensils
  (made from Plantware, a brand of PLA)
- Eco Products utensils
  (made from plant starch material—PSM)

Two brands of cups were tested. Of the two cups, one was for cold beverages and the other for hot liquids. Eco Products Cold Cups, made from PLA and commonly used at events as a substitute for throwaway plastics, did fragment into large pieces on land after two years, with its original volume seemingly intact. In the ocean, there was no recognizable change after two years, despite some warping of the cup's underside. The hot liquids cup, called "Planet", had lost all of it's paper in one year on land, and after two years in the ocean. The thin PLA lining however remained, though fragmented, on land and in the ocean.

There were two straw brands: Aardvark paper straws and World Centric PLA straws. The paper straws fragmented and were quickly unrecognizable on land, and in the ocean. The PLA straws remained unchanged in all environments after two years, with minimal fragmentation.

The two utensil brands were Rossetto and Eco-Products. The Rossetto utensils (all knives) are made from Plantware, a brand of PLA. In both land and sea there was no change, only discoloration. Eco-Products utensils, made from Plant Starch Material (PSM), performed similarly to the Rossetto utensils, with no observed change. PSM is a blend of plant starch and polypropylene and is not meant to be compostable. The company admits that their product does not meet ASTM6400, but is a step away from plastics based on fossil fuels.

ECO PRODUCTS COLD CUPS



"PLANET" COFFEE CUP

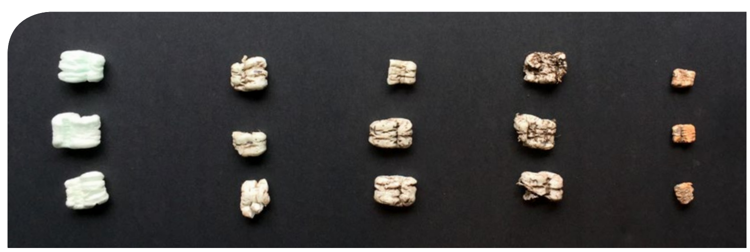
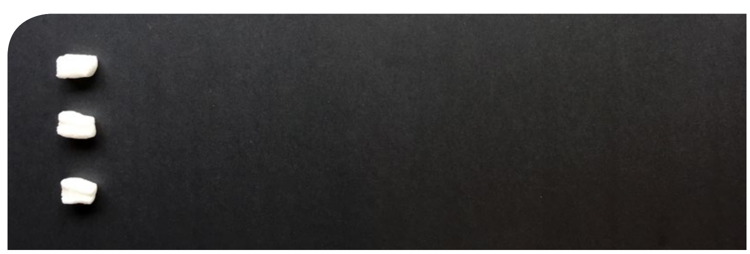
AARDVARK PAPER STRAWS

WORLD CENTRIC PLA STRAWS

ROSSETTO UTENSILS

ECO PRODUCTS UTENSILS

MISCELLANEOUS POLYMERS: PHA, PLA, STARCH, POLYSTYRENE

PRODUCT	STANDARDS & CLAIMS	ENVIRONMENTAL PERFORMANCE New / 6 mo. on land / 12 mo. on land / 24 mo. on land / 24 mo. in the sea
 Dansa LLC Sink Strainer	100% Biodegradable 5 months, corn starch.	
 Papermate PHA Pen	Biodegradable in soil/ compost in 1 year	
 C-Line Binder Divider	Biodegradable to ASTM D5511. Polypropylene. EcoPure, 2-5 yrs in landfill.	
 Zoe B PHA Beach Toys	First biodegradable beach toy.	
 Packing Peanuts	Foam polystyrene	
 Packing Peanuts	Starch	

MISCELLANEOUS POLYMERS

There were six products compared in this category:

- Dansa sink strainer
- Papermate pen (made from PHA)
- C-Line Binder Dividers
- Zoe-B beach toy (made from PHA)
- Packing peanuts (foamed polystyrene)
- Packing peanuts (starch)

Two were products using the polymer polyhydroxyalkanoate (PHA), a beach toy cup and a Paper Mate pen. Two were foam packing peanuts, one made from starch and the other polystyrene. We also tested a sink strainer that was labeled 100% biodegradable and made from 100% cornstarch. Lastly, we found a folder binder divider made of polyethylene, and labeled "Biodegradable" due to the additive with the brand name "EcoPure".

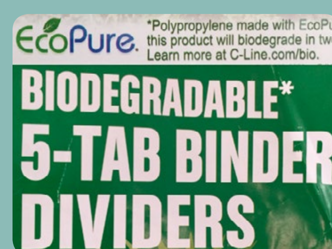
The results were fascinating. The packing peanuts performed as expected. The starch ones completely degraded in all environments and time frames, while the polystyrene packing peanuts were unchanged. The folder binder divider, while labeled clearly as biodegradable and used ASTM D5511 to imply degradation, remained unchanged on land and sea in our experiment. Their branded polymer EcoPure is described on their website as an additive that "allows microbes to create a film that coats the plastic waste," increasing biodegradation rates in a landfill setting. In our experiment nothing happened. There was no pitting or discoloration on the plastic surface.

The sink strainer, made from 100% cornstarch, advertised 100% biodegradability, and included a series of three photos of the strainer disappearing in a home composting environment in 5 months. In our study, the sink strainer remained unchanged after two years on land and in the ocean.

The PHA products performed the best. The Paper Mate pen had PHA components combined with metals and other plastics. Only the PHA components were tested, and in two years on land they began to fragment. Degradation was nearly complete after two years in the ocean, with only a few observable fragments remaining.

The PHA beach toy, labeled as biodegradable, remained whole after 2 years on land, though cracked and pitted. It even had a plant growing out of it two years later, with the ball of roots nestled inside the cup. Impressively, in the ocean it had completely decomposed with no fragments observed.

DANSA SINK STRAINER



C-LINE BINDER DIVIDERS

PAPERMATE PEN

ZOE-B BEACH TOY

THE SOLUTION STRATEGY

For most of the items on the Plastics Better Alternatives Now List 2.0, the best alternative is to replace harmful plastic products with reusable/refillable products that can provide the same service without using any disposable materials at all. We call this a "functional replacement" of an unnecessary, harmful plastic product.

In many cases, the next best strategy is to substitute the harmful plastic product for another disposable product that is readily biodegradable in the environment, such as paper straws and bags. Compostable materials that biodegrade in commercial composting facilities and meet established standards (ASTM D6400 or D6868) are widely available as an alternative material for many plastic packaging and food service ware products. While these biopolymers do not perform well in the environment, land or sea, they are a step away from fossil fuel-derived plastics.

We recognize that plastic helps to provide important product protection by preventing contaminants from spoiling food. Innovation will play a critical role. Consumer goods and food service companies should invest in truly biodegradable packaging technologies that allow comparable levels of product protection—without harm. And where fossil fuel based plastics are still being used in consumer products, we recommend increasing recycled content over time, ideally reaching 100% post-consumer recycled content. This will help to better foster a circular economy, spur design innovation and increase efficiency.

The best alternative is to replace harmful plastic products with reusable or refillable products that can provide the same service without using any disposable materials at all.

Better Alternatives

1. FOOD WRAPPERS & CONTAINERS

Beyond cigarette butts, food wrappers and other types of food packaging are the most abundant items found in the environment. From potato chip bags and candy wrappers, to cookie and cracker trays, single-use disposable and non-recyclable packaging is everywhere. The impacts are seen across the U.S. and in the trillions of plastic particles floating in the ocean, where they accumulate toxic chemicals and are ingested by marine wildlife.

Better Alternatives

Grocers and food-service establishments are key to giving consumers a choice of products and packaging to consume. Many grocers have adopted mission statements reflecting their values, like minimizing waste and improving the quality of their products. Examples include providing opportunities for bulk purchasing, incentives for bringing reusable bags and containers, eliminating single-use plastics from product lines and food service counters, as well as improving recovery and recycling of plastic film used to wrap pallets.

Restaurants are increasingly eliminating disposable packaging from their businesses. Programs like Surfrider's "Ocean Friendly Restaurant"[24] guide businesses toward zero waste practices. They largely focus on eliminating single-use packaging from to-go orders, but also eliminate waste indoors by providing straws only on request and then, offering paper straws.

2. BOTTLE & CONTAINER CAPS

Because bottle caps are thick and float in seawater, they fragment slowly, and are commonly found adrift and washed ashore on remote beaches worldwide. Marine life often mistake them for food. For some seabirds, such as the Laysan Albatross in the North Pacific or the Fulmar in the North Atlantic, ingestion of bottle caps and their fragments are common. This can cause perforations to the gut lining or a false sense of satiation resulting in less feeding, malnourishment and vulnerability to illness.

Better Alternatives

Using reusable bottles for water, soda and other beverages solves this problem. For commercial beverages sold in PET (#1), and HDPE (#2), companies can employ "Connect the Cap" technology to ensure that the cap stays attached to the bottle. Manufacturers should begin voluntarily making this change; policymakers can speed the process by advancing "Connect the Cap" legislation. Advances in recycling technology now enable both the bottle and cap (which are made from different plastics) to be recycled together.[25]

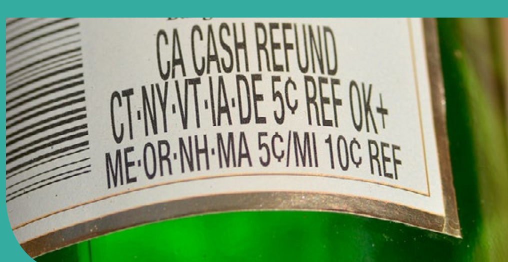
BOTTLE RETURN & RE-USE

THROUGHOUT CANADA brand-owners and beverage bottle importers finance the majority of container recycling and recovery costs through payments directly to municipalities to collect, process and find markets for recyclables. These costs have and likely will be borne by industry through proposed legislation. To date, many cities have used these funds on recycle bins and public awareness campaigns, resulting in a successful model to follow.

Canada's overall recovery rate for refillable and nonrefillable bottles is estimated at 66%. Of this amount, refillable beer, representing a minority of total beverage sales (19%), is recovered at a collection rate of 98%. Non-refillables, which comprise the majority of containers (81%) has an estimated collection rate of about 59%. Combined, Canadian deposit systems have a total recovery rate of 83%, while non-deposit systems have a total recovery rate of 41%, when all containers sold and recovered at home and away-from-home are accounted for (Morawaski, 2010)*.

Beverage bottlers, retailers and distributors are increasingly taking responsibility for the full lifecycle of their materials, with the aim of increasing efficiency, uniformity, consumer buy-in, all the while limiting impact on sales. Canada's models for industry participation in the circular economy is successfully shifting responsibility to the producer.

It is a model the U.S. can replicate in order to expand current U.S. bottle redemption programs beyond the 10 states that have them currently.



** Morawski, C., 2010. Who pays what: An analysis of beverage container recovery and costs in Canada. CM Consulting, Ontario, Canada.*

3. BEVERAGE BOTTLES

Across the U.S. plastic bottles, including PET (#1), HDPE (#2) and PP (#5), are recycled at a rate of 29.7% in 2016, a decrease from previous years.[26] Recycling of plastics is competing with cheaper new ethylene from producers, which is affecting the value of recycled material worldwide.[27]

Bottles of all kinds are ubiquitous as waste, and are common on remote beaches worldwide, often carrying hitchhiking marine life, called "invasive species" across oceans.

Better Alternatives

Much of the waste from bottled water can be eliminated through investing in easy-to-access public drinking fountains and water bottle refill stations. Soda and juice bottle waste can also be cut down through strategies to encourage refillable containers at specialized fountains. Businesses, institutions, universities and schools can all contribute by phasing out bottled water and encouraging reusable/refillable bottles and cups for water and other drinks. For commercially sold drinks in PET and HDPE bottles, policymakers can also help decrease litter and boost recycling by increasing the container-deposit for these bottles. Research shows these policies work: In Michigan, the state with the highest container deposit of 10 cents, container-recycling rates are at 94%, the highest in the country.

4. PLASTIC BAGS

Ubiquitous in the environment, plastic bags pose threats to wildlife on land and sea, while polluting our lakes, rivers, beaches, and ocean. Plastic bags are "escape artists" blowing out of trash cans, landfills, getting stuck in trees and tall fences, as well as clogging storm water drains, all of which are added costs to municipal waste management and create urban blight. Increasingly, animals like goats, cows, horses and camels, are treated for plastic bag ingestion, which results in blockages, dehydration, starvation, or sepsis from bacterial infections. Plastic bags can also damage recycling infrastructure at Material Recovery Facilities and lead to costly shutdowns and repairs. When they are collected, they are often too dirty for domestic recycling markets, and therefore often exported to South East Asia where environmental and worker health standards are low or nonexistent.

Better Alternatives

Studies show that plastic bag pollution can be dramatically reduced through policies that place fees on bags or ban their use outright, as well as encouraging reusable bags. Disposable shopping bags made from high-recycled-content paper or other non-plastic, biodegradable alternatives help prevent plastic pollution. Grocers, retailers and take-out food service establishments can implement in-store policies to encourage reusable bags and phase out disposable plastic ones.

5. STRAWS & STIRRERS

Plastic straws and coffee stirrers are also common throughout the United States, topping the list on trash surveys. They're everywhere, and like bottle caps, plastic straws float. They threaten wildlife and contribute to the growing ocean plastic epidemic.

Better Alternatives

Restaurants and food-service establishments can help by switching to a "straws upon request" policy and by providing paper, rye wheat, bamboo, reusable glass, steel or metal straws for eat-in dining. For take-out, 100% paper straws can be substituted for plastic, while coffee shops can provide reusable spoons or wooden stirrers. Some paper straws have a plastic lining, which should be avoided. Policymakers should look to plastic straw bans combined with "straws upon request" requirements as a way to encourage universal adoption of these changes.

6. LIDS

Coffee and beverage cup lids are another high-pollution item. Coffee lids are typically made from polystyrene; styrene, a primary component of polystyrene, is a suspected human carcinogen. Workers in polystyrene factories are at greatest risk for harmful health impacts from styrene exposure.[28]

Better Alternatives

The best solution is for coffee shops to encourage customers to bring reusable cups with lids, through discount incentives. Soda lid waste can also be cut down through strategies to encourage refillable containers at soda and juice fountains. While some companies have recently switched from polystyrene to polypropylene lids, we suggest the next best alternative would be to substitute with a compostable or biodegradable lid. Another important consideration is the role heat plays in drawing volatile compounds out of any plastic, therefore it is especially important that any lid designed to contain hot liquids be free of harmful additives.

7. UTENSILS

Disposable plastic utensils are another common item found in the environment with deadly consequences for marine mammals, sea turtles and birds that ingest the sharp, rigid particles from fragmented plastic forks, knives and spoons.

Better Alternatives

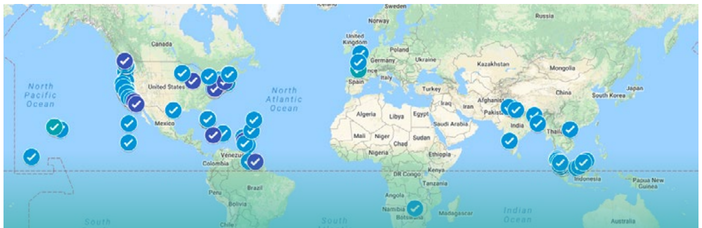
Restaurants and food service establishments can help solve the problem by replacing disposable plastic with reusable utensils. Research shows that going reusable saves money over disposables even when figuring in the increase of capital investment and some increased labor costs. For take-out, restaurants can also encourage customers to use their own utensils, and substitute single-use, biodegradable options such as bamboo for plastic when customers haven't brought their own. Policymakers can speed these changes by banning non-recyclable plastic utensils.

8. CIGARETTE BUTTS

For the purposes of this report, cigarette butts were assessed by the pack since they are purchased in packs of 20. The ubiquity of cigarette butts, despite increases in municipal ordinances to curb smoking in public spaces, suggests that the public still misunderstands what they are made of as well as their toxicity and persistence. Cigarette butts are made from fibrous cellulose acetate and other plastics; they are non-biodegradable and leach toxins into the environment.

Better Alternatives

Obviously—for so many reasons—the best alternative is not to smoke. For those who do however, there are biodegradable cigarette filters that can replace plastic.[29] In light of this design opportunity cigarette companies should aggressively switch to biodegradable filters, and policymakers should look into



The global distribution of policy initiatives to address polystyrene waste.[30]

SOLVING THE POLYSTYRENE PROBLEM

BETTER KNOWN AS STYROFOAM, polystyrene foam (or EPS, expanded polystyrene) is often the most abundant item counted in the environment, largely because of its ability to fragment into smaller pieces. This means that EPS products often shred, and are therefore wildly underrepresented in this study's attempt to determine their numerical abundance.

Their ubiquity, durability, and ability to accumulate high levels of persistent pollutants make degraded EPS products harmful in the environment, particularly when UV degradation causes the polymer polystyrene to break down into the monomer styrene. Recycling EPS has been a failure in most cities because of food waste contamination, and the difficulty of recovering high volumes of EPS. its low market value. Replacing EPS is a high priority.

There are natural packaging alternatives—such as mushroom foam and starch-based packing peanuts—as well as certified compostable plates, cups and bowls, which are becoming more economically viable as a cost-competitive replacement. Schools are getting rid of EPS lunch trays. University and government facilities are replacing EPS packaging. The list of complete or partial polystyrene bans is sweeping the United States. The tide is turning.

Polstyrene packaging can be replaced with 100% home comopostable mushroom packaging.

requiring cigarette companies to make the switch.

Many municipalities are increasing public containers for cigarette butt waste. The organization Surfirder recently instituted a program titled, "Hold onto your Butt", to encourage users to carry their cigarette butts with them until they find a suitable waste bin.

9. TAKE-OUT CONTAINERS

Not surprisingly, plastic take-out containers are some of the most-widely found items in litter surveys. Primarily made from polystyrene foam or thermoformed PET, these products are another high-pollution item.

Better Alternatives

Restaurants and food-service establishments can institute strategies to support customers using reusable or bringing their own take-out and take-away containers. For example, restaurants, grocers and food purveyors can provide reusable containers with deposits to bring back to stores, discounts for bringing your own take-out containers, and non-plastic biodegradable alternatives for customers that don't have them. Companies should focus on making the switch to these alternatives and pushing for reusable and compostable take-out containers made without toxic chemicals. Policymakers can support this transition by banning polystyrene take-out containers and supporting changes in health-codes to enable the use of reusable containers. In some cases, certified compostable biomaterials are a viable and functional alternative. However the use of persistent, hazardous chemicals in food contact materials can negate the benefits of using certain compostable packaging. Greater transparency is needed about the chemical safety of food packaging. In addition, a viable composting infrastructure is needed to ensure the materials are actually composted.

CONCLUSION

B.A.N. LIST 2.0 IS A CALL TO ACTION!

The ubiquity of single-use plastic packaging as a pollutant across our land and waterways is unacceptable. But there are solutions that can move us toward zero waste, eliminating our dependence on single-use plastic and restoring the health of our planet. Hundreds of organizations are now working together to lead the way, demanding that producers take responsibility for the full life cycle of what they create. The public can no longer be expected to bear the sole burden of addressing this legacy of pollution. The brand owners whose products and packaging appear on this B.A.N. List must make changes, and individuals, as their customers, must demand that they do.

Moving forward, there is an important role for businesses in the United States to demonstrate global leadership to solve plastic pollution. For example:

- Many of the major fast-moving consumer goods companies, packaging suppliers and plastics manufacturers are headquartered in the United States. The decisions made in board rooms here have ripple effects throughout the world.
- A significant amount of the global consumer economy is driven by North American brands and exported globally so a consciousness shift here can help lead to transformation around the world.

Through mapping the system with leading experts, our analysis shows the most effective strategies to solve plastic pollution are to: **a)** drastically reduce and eventually eliminate the use of plastic for single-use-disposable products and applications, **b)** develop reusable systems for appropriate to-go food and beverage products, while **c)** advancing extended producer responsibility (EPR)—which makes consumer goods companies responsible for financing collection and recycling—to manage the remaining plastic in commerce.

We're going to need companies—in all shapes and sizes—to recognize that the indiscriminate use of disposable plastic packaging is a liability for their business and could negatively impact customer loyalty. We need them to see the advantages and market opportunities inherent in more sustainable reusable packaging systems and non-plastic packaging alternatives.

In addition, we need city governments across the U.S. to prioritize action on plastic pollution. They need to work with business to implement the policies and solutions that can transform our throw-away-society, with reusable to-go food and beverage systems along with the supporting infrastructure.

EXTENDED PRODUCER RESPONSIBILITY

Extended Producer Responsibility (EPR) is our goal. This strategy integrates environmental and social justice costs into the life cycle and market price of products. Over a billion people in more than 50 countries live in jurisdictions where producers bear some or all of the cost of managing packaging when consumers are finished with it. In Europe, EPR programs for packaging have existed for decades, yet with the exception of container-deposit laws commonly called bottle bills—EPR for packaging programs do not exist in the United States.

- The 20 products on the B.A.N. List represent a design flaw, resulting in their ubiquity as waste. The industries that make these products have an opportunity to design the solution, which can include a range of possibilities: reusable alternatives, materials that are recyclable within a technical or biological system, or even simple reduction.
- Recycling must always come second, after reduction. The new narrative is about less waste, not solely waste management on the citizens' dime. Municipalities and taxpayers no longer want to subsidize increased waste management fees due to the proliferation of over-packaged and poorly designed products. EPR is about corporations transforming their product delivery systems to align with a circular economy.

It is imperative that corporations step up to the plate, be accountable for product design failures, and work on the solutions outlined in this report. B.A.N. List 2.0 is about equitable accountability between industry, government, and consumers. With shared responsibility, solutions will come.

HOLDING BRANDS RESPONSIBLE

When we scoured datasets across the U.S. for trash on the ground and in our waterways, we found lists of products and packaging, but a lack of specific brand names. This results in a skewed focus on consumer behavior for littering and government responsibility for waste management while neglecting producer responsibility for the lifecycle of what they create and sell. Though brand data is scarce, this is changing.

The mobile app Litterati encourages users to assign brands to the products and packaging they photograph. With improvements in machine learning, Litterati is getting better at identifying brands. For B.A.N. List 2.0 we were able to assign brand data to 8 of the top 20 items picked up across the U.S. For example, in the most abundant category—food wrappers—the brands *Wrigley's*, *Trident*, *Swisher Sweets*, *Starburst* and *Snickers* topped the list. For cigarette butts, the brands *Marlboro*, *Camel*, *Parliament*, *Newport* and *Pall Mall* were listed as the top polluters. These data are critical for advocacy campaigns. They can also be useful for the brands themselves to address product design choices prior to potential policy demands.

CONCLUSION

In this two-year study, 5 Gyres demonstrated that across the United States, single-use plastic products and packaging do not degrade and persistently pollute our environment. Significant environmental and economic harm is caused by this waste, yet producers have been let off the hook because the existing economic structures place responsibility to address the problem on individual taxpayers and municipalities. The brands associated with the plastic pollution documented in this study must be held accountable. They need to take part in revolutionizing the design of their products and packaging. Further, the economic systems that promote such waste must be revamped. They need to become part of the global network of organizations, governments and businesses that are advancing Zero Waste initiatives and the Circular Economy. For the health of life on our planet now and for future generations, we must usher in alternatives that promote more responsible stewardship of our natural resources.

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Acknowledgements

We would like to thank Literatti for providing brand data on the B.A.N. List product categories. • Also, Dianna Cohen for art direction for the design of this guide and Wayne M. Deselle/deselle.com for completing the graphic design of this document, and the staff of the Global Wave Conference 2018 held in Santa Cruz, CA for allowing B.A.N. List 2.0 to be launched there. • The biodegradation study could not have been completed without the hard work of students from Team Marine, an ocean conservation organization based on the campus of Santa Monica High School, in California. • The BAN list dataset was compiled and merged by Win Cowger, Graduate Student in the Gray Lab (UCR, Environmental Science)

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Additional Resources

- **Break Free From Plastic**—a global movement envisioning a future free from plastic pollution.
  www.breakfreefromplastic.org
- **The Last Plastic Straw**—Is helping shift away from single-use plastic straws.
  www.thelastplasticstraw.org
- **Nix the 6**—A campaign to eliminate single-use polystyrene and expanded polystyrene foam ("Styrofoam") plastics.
  www.5gyres.org/polystyrene
- **Ocean Friendly Restaurants**—Reducing single-use plastics and raising customer awareness at restaurants nationwide.
  https://www.surfrider.org/programs/ocean-friendly-restaurants
- **Plastic Bag Laws**—A resource for legislative bodies considering laws limiting the use of plastic bags.
  www.plasticbaglaws.org
- **Plastic Pollution Coalition**—A global alliance of individuals, organizations, businesses, and policymakers working toward a world free of plastic pollution and its toxic impacts on humans, animals, waterways & oceans, and the environment.
  www.plasticpollutioncoalition.org
- **Rise Above Plastics**—Offers a community action plan and information for addressing single use plastics.
  http://www.surfrider.org/programs/rise-above-plastics